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Climatological Livestock Studies
in the United States 1

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In the United States increased attention is being given to the environmental physiology of livestock and poultry. At present nineteen Land Grant Colleges and the U. S. Department of Agriculture have laboratory facilities and others are conducting studies under field conditions (4) 2/Fifteen of the institutions have work in progress on poultry, six with cattle, four with swine and a similar number with sheep. These activities are coordinated to a large extent through regional projects on such things as housing requirements and adaptability. These include the nature of factors which may limit production in certain areas, physiological characteristics of adaptability and breeding and management methods. The progress of the general findings will be discussed by species.

Dairy Cattle

Exploration of methods of combining inherent adaptability and productivity is in progress as part of the Southern Regional Dairy Cattle Breeding Project (S-3). Three general approaches are being followed: (1) the introduction of adaptability characteristics through various combinations of Red Sindhi and Brahman cattle with European breeds; (2) selection within existing breeds for greater adaptability and productivity; and (3) hybridization of existing breeds by: (a) continuous crossing and (b) developing new strains from a crossbred foundation. These studies are being conducted by USDA and in cooperative projects with the States of Georgia, Louisiana and Texas.

The results of the Red Sindhi-Jersey crossbreeding experiment have been analyzed. When the crossbreds at Beltsville, Maryland; Jeanerette, Louisiana; and Tifton, Georgia, were compared with their purebred Jersey stablemates, it was found that the F₁ crosses averaged 23% lower in milk and 18% lower in butterfat; the F₂ crosses produced 34% less milk and 37% less butterfat; the 1/4 Sindhi-3/4 Jersey crosses were 11% lower in milk and 25% lower in fat; and the 3/4 Sindhi-1/4 Jersey group averaged 57% less milk and 54% less fat. The crossbreds also showed less persistency than the Jerseys. In all of the Sindhi crosses it was found that temperament was a limitation in the usefulness of the crosses.

1/ Paper presented by R. E. McDowell at the Fourth Inter-American Meeting on Livestock Production held July 1958 at Kingston, Jamaica, B. W. I.

2/ Figures in parentheses refer to recent literature cited, p. 7.

As with the Sindhi-Jersey crosses it appeared that the crossing of Red Sindhi and Holsteins did not provide a satisfactory method of producing cattle adaptable to the South. The F₁ crosses at Louisiana State University and Beltsville averaged approximately 50% less in production than their purebred Holstein stablemates. The performance of these crosses has been similar to the Jersey crosses in showing poor persistency and fractious temperaments.

The production of the Sindhi-Brown Swiss crosses has also been lower than purebred Brown Swiss under the same conditions. The productive level of the Brahman-Jersey crosses has been disappointing up to this time.

In view of the findings with the Red Sindhi crosses and the sample of Sindhis available, it appears that other avenues of approach probably will be more satisfactory for conditions existing in the United States. Evidence is accumulating to show that there is a rather wide range of adaptability within breed groups. Studies of the comparative heat tolerance of Jersey and Red Sindhi-Jersey crosses have also shown there is a great deal of variation within breed groups. Some of the purebred Jerseys even exhibited more heat tolerance than the crossbreds. It appears, therefore, it may be practicable to follow a breeding and selection program within the European breeds in order to develop the most desirable combinations of adaptability and productive performance; hence, the initiation of the other three systems of breeding for adaptability in the Southern United States. The new projects have not advanced, however, to the point that results are available at this time.

In studies of the effect of various climatic elements on the responses of cattle, air temperatures above 80°F. have been found to be the most important influence on production, feed consumption, body temperature, respiration rate and pulse rate. Solar radiation, vapor pressure and wind velocity follow in that order of relative influence. The degree of effect of these elements is dependent upon breed, age, stage of lactation and level of nutrition.

Reports from the climatic laboratories at the University of Missouri, Louisiana State University and Beltsville indicated that the ability of cattle to utilize respiratory activity effectively under hot conditions varies quite widely within and between breed groups. Respiratory volume has been found to be a better index of the effectiveness of respiratory activity than respiration rate. It has also been found that high respiratory rates under hot conditions may develop a respiratory alkalosis as a result of a decline in CO₂ - combining power of the blood.

Results from the Missouri Climatic Laboratory have shown that European cattle vaporize moisture from the skin at a lower rate per unit of surface area than Zebu cattle. Shorthorn heifers were found to have a higher surface evaporation rate than Santa Gertrudis or Brahman heifers

but the evaporation rate of the Brahman continued to rise with increasing air temperature; whereas, the Shorthorn showed little or no change above 80°F. (3). Studies at Beltsville indicated that rate of evaporation increases with increasing air temperature, varies with different areas of the body (dewlap and appendages being low) and once initiated is maintained at a relatively uniform rate. Evidence is accumulating that the major portion of the moisture available for evaporation comes from the sweat glands and rate of sweating varies within and between breed groups.

Studies on Red Sindhi bulls in the psychrometric chamber at Beltsville before and after removal of the dewlap showed no appreciable difference in the rectal temperature or respiratory responses of these animals on either occasion. The same was found to be true after removal of the hump and about four inches of each ear. A comparison of the number and size of blood vessels in the dewlap and the skin of the mid-neck region showed that the neck vessels were much larger and more numerous than in the dewlap area. These results indicate that the dewlap and hump of the Zebu are not of great significance in heat regulation.

U. S. workers are of the opinion at this time that differences in ability to dissipate heat do not explain adequately the observed differences in heat tolerance. The belief is fast growing that lower heat production is more important to good performance under hot conditions than the ability of the animal to lose heat. Studies at Louisiana have shown that the heat production of Sindhi-Holstein crossbred cattle is less than that of Jerseys or Holsteins. The ratio of heat produced per square meter of surface area indicates that the crossbreds only had to lose 57% as much heat as the Holsteins and 76% as much as the Jerseys. The lower heat load of the crosses appeared to be due to a lower basal metabolic rate since the heat increment per pound of FCM was the same for all groups. The indications are that cows of European breeds tend to decrease heat production to a much greater extent than Zebu types when exposed to hot conditions. Because of the many factors which influence the heat production of an animal, more extensive studies are required in this field before results can be conclusive.

Results of studies of the influence of nutrition and management on adaptability indicate shade may be an economical and effective means of maintaining summer milk flow, particularly in the less humid areas. Also the cooling of drinking water may prove beneficial but differences in the temperature of the drinking water and the environmental temperature should probably not exceed 20-25°F. It has been found that at environmental temperatures of 90°F. and above the cooling of water to as low as 50°F. causes a decrease in water consumption. Short-time cooling of the animals in an air conditioned chamber appears to aid in the comfort of lactating cows but it is not an effective means of improving summer production. The reduction of the fiber content of the grain ration

for dairy cows has proven an effective means of maintaining summer milk flow. From present results indications are that nutritional conditions, during hot summer weather in the South, exert a more marked effect on milk production than do direct climatic effects but much more work is required to resolve the importance of each.

Results of a study of climatic patterns indicated that even in hot and humid regions there is so much variability in the climate that the results of adaptability research at any station have to be interpreted in relation to the specific climatic conditions existing at that station and during that particular period (2).

Beef Cattle

Results of the analysis of heat tolerance data covering a ten year period at the Iberia Livestock Experiment Farm, Jeanerette, Louisiana, showed correlations between respiration rates and body temperatures in crossbred cattle from 0.5 to 0.6 but these were not considered sufficiently high to justify the use of respiration rates as a measure of heat tolerance. The correlations between dam's coefficient of heat tolerance and production, as measured by her own weights at birth, six months and five years and those of her progeny at the same ages, were not significant. The same correlations using respiratory rates instead of heat tolerance coefficients were also not significant. From this study it appears that selection on the basis of beef production automatically includes selection for necessary heat tolerance but the converse is not true.

At the Imperial Valley Field Station, El Centro, California, where the climate is hot and dry, shades have been found to reduce the radiant heat load of beef cattle up to 50% (1). Experiments indicate that ten to twelve feet is the best height for cattle shades: Although east-west orientation is best from the standpoint of reducing the radiation heat load those orienting north and south improved sanitary conditions. Proper orientation of corrals to take advantage of air movement is also important. Employment of large fans operating full or part-time to increase air movement over penned cattle showed a definite advantage for mechanical cooling. Location of corrals away from buildings also aids in reducing the radiant heat. Hay proved to be the coolest of all materials tested for roofing although it provides problems of replacement. Painting the top-side of a metal roof white reduced the radiant heat load under the shade considerably and painting the under-side of the roof aided in reducing the radiant heat load because the black paint absorbed radiation from the ground rather than reflecting it back on the animals. Ground cover and color are also factors in determining the radiation received by animals. Indications are that about 60 square feet per head is adequate for shade. Wire or cable corrals were found to be more satisfactory than wood for fencing since they offer little resistance to natural air movement, and also offer relatively little area for absorbing solar radiation.

Preliminary results of shade studies in the more humid areas of the southeast with grazing steers and dairy cattle have not shown the advantages found in dry areas.

Also in California the use of sprays, hoses and other methods of wetting animals was not found to be successful unless the animals were wetted to the skin. Cooling of drinking water to about 65°F. improved animal comfort and gains were increased. It was also found that the proper ration for hot weather was extremely important in beef production. Care should be taken not to supply high fiber diets during the summer months as such feeds produce a high heat increment which must be dissipated by the body. In general, a summer ration should be a good quality roughage and a grain of rather low fiber content.

At the University of Missouri three breeds of beef type heifer calves; Brahman, Shorthorn and Santa Gertrudis, were divided into two groups each consisting of three calves from each breed (3). One group was held at 50°F. and the other at 80°F. for a period of about one year. The Brahman calves in the 80°F. chamber gained slightly faster than the Zebus in the 50°F. chamber. Santa Gertrudis did equally well in both chambers. Shorthorns in the 50°F. chamber were about 200 pounds heavier than their counterparts in the 80°F. chamber at the end of the project. Short tests made after the year at the constant temperature indicated very little if any acclimatization of the calves. Breed differences in heat tolerance were found to be inversely related to heat production per unit of weight. The Brahmans, which had the lowest rate of heat production, were most heat tolerant. Shorthorns, which had the highest rate of heat production, were least heat tolerant. The Santa Gertrudis were intermediate in both respects.

Sheep

In order to determine the relative importance of factors such as location, climate and nutrition on the various productive traits within breeds of sheep, 40 yearling Rambouillet rams from the U. S. Sheep Experiment Station at Dubois, Idaho, were placed at several locations in March 1957. The rams were divided into eight groups that were equal in body weight classes. Two groups were placed at State College, New Mexico; Tifton, Georgia; Beltsville, Maryland; and Dubois, Idaho. One group of rams at each location was being managed under customary practices used at the station. The other rams were placed in individual pens and at all locations were fed the same levels of alfalfa pellets from a single source. All rams were shorn in April-May 1957 and again in April-May 1958. At the end of the first year, 24 of the rams were transferred among locations so that one ram from each group at each location would spend the second year with a comparable group at another location. The average weight gains of the individually fed rams for the first year were as follows: 81.4 lbs. at Beltsville, Maryland; 77.8 at Dubois, Idaho; 71.0 lbs. at Tifton, Georgia; and 68.0 lbs. at State College, New Mexico; while the gains over a similar period for the group fed rams were: 35.6, 32.4, 79.4 and 62.8, respectively for the four locations. The average gains in grease

fleece weights between the 1957 and 1958 shearings for the individually fed rams were 7.7 lbs. at State College, New Mexico; 7.1 lbs. at Beltsville, Maryland; 6.8 lbs. at Tifton, Georgia; and 5.5 lbs. at Dubois, Idaho; while the gains in fleece weights for the group fed rams were: 3.2, 3.0, 5.2 and 2.1 lbs., respectively. These preliminary results indicate climate as well as nutritional effects between stations.

Preliminary results of a study at Beltsville, Maryland, of the effect of season and length of day on wool growth of Merino, Hampshire and Columbia x Southdale rams indicated no definite seasonal trend or growth patterns.

In an attempt to control semen quality by changing environmental temperatures, results from the University of Kentucky showed that during the summer months rams kept at 45-48°F. fertilized 64% of the ova while rams kept outside fertilized only 26%. The Mississippi station also has found that rams kept at 65°F. produced semen of higher quality and were able to settle more ewes than rams kept outside. Shearing of rams during periods of exposure to high temperatures tended to prevent decreases in semen quality. Investigations with ewes at Mississippi have shown that 35 day non-returns could be increased during the summer months when ewes were kept at a temperature of 65°F. for 20 days post-mating. Cooling either the ewe or ram resulted in a non-return rate of about 40%. When both the rams and ewes were kept cooled the non-return rate was increased to about 60%. There are also indications that a constant high temperature is more detrimental than a high but variable temperature in fertility of sheep. The ova of ewes under constant high temperatures may be affected directly prior to fertilization. A less severe temperature may also bring about a change in uterine environment so as to cause death of the embryo prior to the time of implantation.

Swine

Extensive work at the University of California under control conditions in a psychrometric chamber indicated that live weight is significantly related to the temperature at which maximum gains are obtained. Pigs weighing 100-150 lbs. exhibited maximum gains at 70°F. temperature; however, in heavier hogs (350 lbs.) maximum gains were obtained at 61°F. At 90°F. gains of less than 1 lb. per day were observed at all weights of 200 lbs. or more. At 100°F. all pigs weighing over 100 lbs. lost weight while those weighing 100 lbs. gained about 0.4 lb. per day. At 110°F. even the 100 lb. pigs lost weight. Efficiency of feed utilization was closely related to environmental temperatures with the most efficient gains being made at temperatures which permitted maximum gains. Efficiency declined very rapidly as the temperature moved away from the optimum.

The use of sprays, fogging and wallows has been found very effective in reducing stress in swine and increasing gains under summer conditions.

Trials conducted by the U. S. Department of Agriculture indicated that environmental temperature is a factor in the performance of swine treated with hormones both in gain and feed efficiency. In one of these trials 150 lb. pigs maintained at 90°F. gained less than 1/3 lb. per day and used nearly 1,000 lbs. of feed per 100 lbs. of gain while those kept at 50°F. gained 1.17 lbs. per day and required only 495 lbs. of feed per 100 lbs. of gain.

At the Michigan State University thiouracil feeding was found to have a pronounced effect on the performance of swine under different temperatures. Pigs kept at 40°F. yielded a higher percentage of loin cuts and a lower percentage of fat trim than animals kept at 80°F.

Androgens have been found to increase the ratio of lean to fat in the carcasses of pigs. The mechanism by which they act has not been determined. There is some indication that the hormones increase activity and thus increase muscular development. However, this is not the complete answer, since there is evidence of changes in electrolytes in the meat and of other metabolic changes when they are fed. When one hormone is administered, there are profound changes in secretion of other hormones. Weather also influences secretion rate of some of the endocrine glands, thereby causing alterations in the requirements of the animal for certain nutrients. There are breed differences in reaction to hormones; Yorkshires react more quickly and to lower doses of certain hormones than Durocs.

Indications are that thyroid hormones can be used to increase milk flow in swine.

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